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How to measure husbandry success? The life expectancy of zoo ruminants

Müller, Dennis W H ; Bingaman Lackey, L ; Streich, W J ; Fickel, J ; Hatt, Jean-Michel ; Clauss, Marcus

Abstract: Relative life expectancy (i.e. the average life expectancy of a species expressed as a percentage of the maximum longevity ever reported for this species) may describe husbandry success in captive populations. By correlating the relative life expectancy with biological characteristics and husbandry factors for different species, reasons for variations in relative life expectancy can be detected. We analysed data for 166,901 ruminants of 78 species and demonstrated the presence of such a correlation between relative life expectancy and percentage grass in the species' natural diet (not necessarily the diet fed in zoos). This suggests that species adapted to grass (so-called grazers, such as bison and wildebeest) can be managed more easily when compared to species that feed on leaves and twigs (so-called browsers, such as giraffe and moose). Another finding of our analysis is a true success story of zoo animal management: the relative life expectancy was higher in species that were managed by an international studbook than in species not managed this way. This highlights the positive effect of intensive studbook management on the overall husbandry success of the respective species. Translating these results into husbandry recommendations, our approach can help to improve zoo animal husbandry.

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ZORA URL: https://doi.org/10.5167/uzh-69849
Journal Article

Originally published at:
Müller, Dennis W H; Bingaman Lackey, L; Streich, W J; Fickel, J; Hatt, Jean-Michel; Clauss, Marcus (2011). How to measure husbandry success? The life expectancy of zoo ruminants. WAZA Magazine, (12):37-39.

magazine
Vol 12 2011

World Association of Zoos and Aquariums
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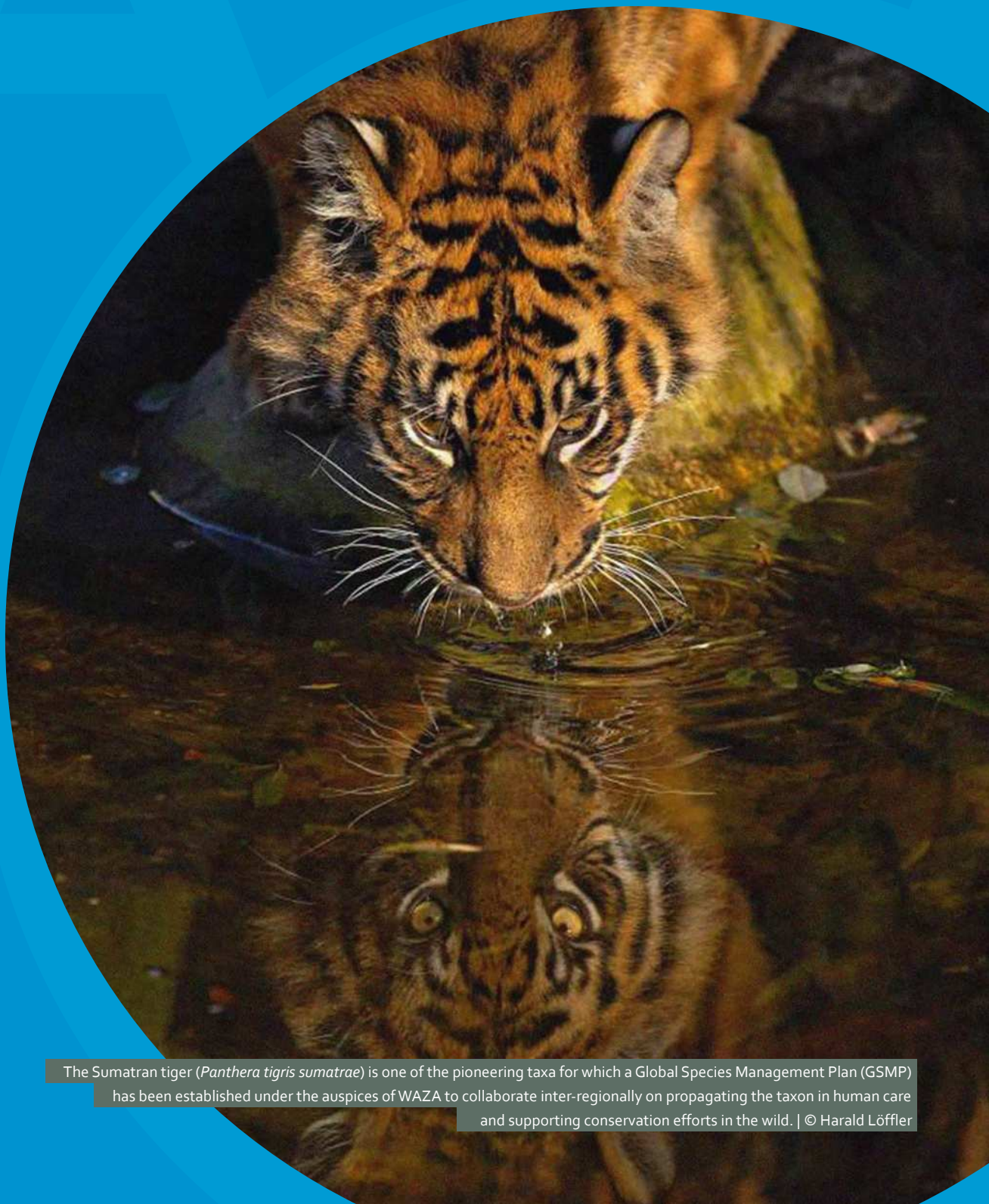
Towards Sustainable Population Management



The Sumatran tiger (*Panthera tigris sumatrae*) is one of the pioneering taxa for which a Global Species Management Plan (GSMP) has been established under the auspices of WAZA to collaborate inter-regionally on propagating the taxon in human care and supporting conservation efforts in the wild. | © Harald Löffler

Contents

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Imprint

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Layout and typesetting:
michal@sky.cz
Print:
Agentura NP, Staré Město,
Czech Republic

Edition: 750 copies

© WAZA 2011

This edition of WAZA Magazine is also available on www.waza.org.

WAZA is a registered interest representative with the European Commission, ID number 30556573017-18.

Printed on FSC paper.

ISSN: 2074-4528

Dennis W. H. Müller[1]*, Laurie Bingaman Lackey[2], W. Jürgen Streich[3], Jörns Fickel[3], Jean-Michel Hatt[1] & Marcus Clauss[1]

How to Measure Husbandry Success? The Life Expectancy of Zoo Ruminants

Summary

Relative life expectancy (i.e. the *average* life expectancy of a species expressed as a percentage of the *maximum* longevity ever reported for this species) may describe husbandry success in captive populations. By correlating the relative life expectancy with biological characteristics and husbandry factors for different species, reasons for variations in relative life expectancy can be detected. We analysed data for 166,901 ruminants of 78 species and demonstrated the presence of such a correlation between relative life expectancy and percentage grass in the species' natural diet (not necessarily the diet fed in zoos). This suggests that species adapted to grass (so-called grazers, such as bison and wildebeest) can be managed more easily when compared to species that feed on leaves and twigs (so-called browsers, such as giraffe and moose). Another finding of our analysis is a true success story of zoo animal management: the relative life expectancy was higher in species that were managed by an international studbook than in species not managed this way. This highlights the positive effect of intensive studbook management on the overall husbandry success of the respective species. Translating these results into husbandry recommendations, our approach can help to improve zoo animal husbandry.

Background

Zoo animal husbandry is aimed at constantly improving husbandry conditions, provision of veterinary care, reproductive success and thus ultimately husbandry success. Important questions arise from these aims: how can husbandry success be measured objectively, and how can we improve it on the basis of scientific results? Although some zoological institutions make a great effort to study various aspects of wellbeing for certain species, comparative analyses needed to determine factors influencing the husbandry success of different species in captivity are rare (Mason 2010).

In 2003, WAZA proclaimed the goal "to exercise the highest standards of animal welfare", leading to the question of how husbandry success and animal welfare can be measured objectively. A comparison of life history parameters such as breeding success per year or life expectancy between a zoo population and a wild population is an option to find out whether a species fares better in captivity than in the wild. In comparing three populations of wild but unhunted deer species with their respective zoo populations, we demonstrated that life expectancies of red deer (*Cervus elaphus*) and reindeer (*Rangifer tarandus*) were within the same range or even markedly higher in zoos, whereas captive roe deer (*Capreolus capreolus*) had a shorter life expectancy than their free-ranging conspecifics (Müller *et al.* 2010a).

We believe that the problems in providing adequate browse to captive roe deer (a typical browser that feeds on leaves and twigs) and problems associated with more crowded conditions in zoos (as roe deer live predominantly solitarily in the wild) may have led to nutritional deficiencies and increased stress, leading to shorter life expectancy in captivity. On the other hand, reindeer and red deer are naturally socially living and are both so-called mixed feeders, adapted to feed moderate amounts of grass. Thus, they cope well in zoos and achieve comparatively high life expectancies. Unfortunately, such analyses will be restricted to a few exemplary comparisons, as reliable data for free-ranging populations are missing for most species. To test our hypotheses that the social system and feeding behaviour of a species in the wild have an influence on husbandry success, we conducted an analysis of the life expectancy of ruminant species (deer, giraffes, cattle, antelopes, gazelles, etc.) in zoos.

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Comparison of Life Expectancy among Ruminants

A comparative analysis of different species' life expectancies in captivity can be used to detect factors that influence life expectancy in captivity. Such factors would consequently have an important impact on husbandry success and also on animal welfare. We used data from approximately 167,000 animals representing 78 ruminant species kept in about 850 zoos around the world (data from the International Species Information System [ISIS]) to calculate the life expectancy of a species' overall zoo population. Life expectancy of different species depends on the body mass of a species – species with a higher body mass such as bison (*Bison bison*) and giraffe (*Giraffa camelopardalis*) achieve higher life expectancies than do smaller species such as roe deer or gazelles (*Gazella* spp.). Comparative analyses of different species' life expectancies require a correction for this effect. This was done by calculating the relative life expectancy of a species in captivity.

The *average* life expectancy of a species was hereby expressed as a percentage of the *maximum* longevity ever reported for this species. Ranging from 0–100%, a relative life expectancy of 0% would denote the death of all individuals at birth, whereas a relative life expectancy of 100% would imply that all individuals reach the maximum longevity for that species. For example, assuming an average life expectancy of 80 years and a maximum longevity of 122 years for women in western Europe, women nowadays have a relative life expectancy of 66%. In zoo ruminants, the relative life expectancy ranged from 27% for moose (*Alces alces*) to 59% for Arabian oryx (*Oryx leucoryx*), with a mean relative life expectancy of 43% (Müller *et al.* 2011). We then tested the influence of several biological parameters (e.g. feeding behaviour, social system) and husbandry measures (e.g. keeping of an international studbook for a species) on the relative life expectancy.

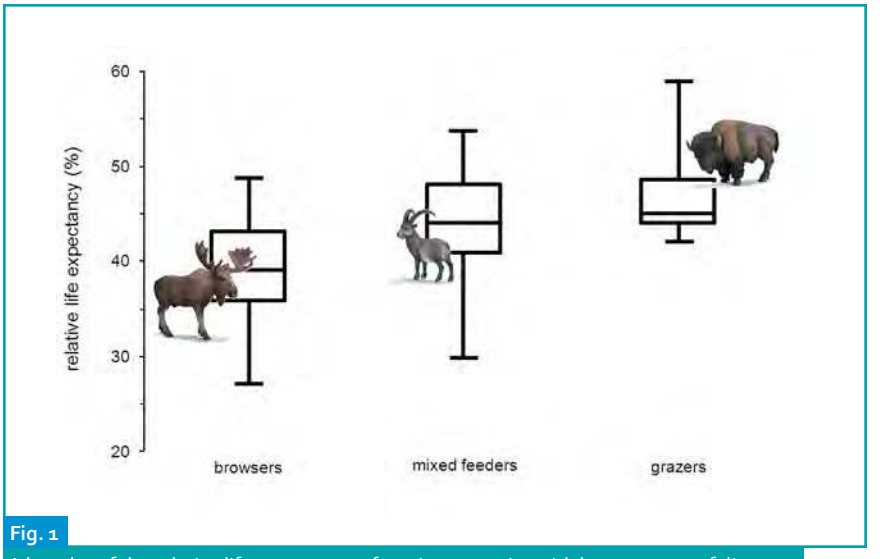

Fig. 1
A boxplot of the relative life expectancy of ruminant species with low amounts of dietary grass in the wild (browsers) in comparison with species that feed moderate proportions of grass in the wild (mixed feeders) and species that ingest high proportions of grass in the wild (grazers). Included are 20 browsers (e.g. moose), 32 mixed feeders (e.g. Alpine ibex [*Capra ibex*]) and 26 grazers (e.g. bison). From top to bottom, boxplots show the highest value, the value achieved by 75% of species, the value achieved by 50% of species, the value achieved by 25% of species and the lowest value of the relative life expectancy. Note that the relative life expectancy was lowest in browsing species and highest in grazers.

The relative life expectancy correlates positively with the percentage of grass in a species' natural diet (not necessarily the diet fed in zoos) (Müller *et al.* 2010b, 2011). Browsing species with a lower percentage of grass in their natural diet (e.g. giraffe, moose) had, on average, a lower relative life expectancy compared with grazing species (e.g. bison, wildebeest [*Connochaetes taurinus*]) that have a high percentage of grass in their natural diet (Fig. 1). Thus, our results confirm the general experience of zoos where browsing species, evolutionarily adapted to eat leaves and twigs, have more nutrition-related problems than mixed feeders (with a moderate proportion of grass in their diet) and grazers. Obviously, these nutrition-related health problems have a significant influence on life expectancy in captivity.

One of the major achievements of zoos in the last century was the conservation of species that had become extinct in the wild, including European bison (*Bison bonasus*), Przewalski's horse (*Equus ferus przewalskii*) and Père David's deer (*Elaphurus davidianus*). A major key to this success was the cooperation and breeding coordination of many zoos with international studbooks. Nowadays, conservation of endangered species by *ex situ* breeding programmes is one of the most important aims of zoological institutions (WAZA 2005), and international studbooks for more than 150 species have been established. Detailed husbandry recommenda-

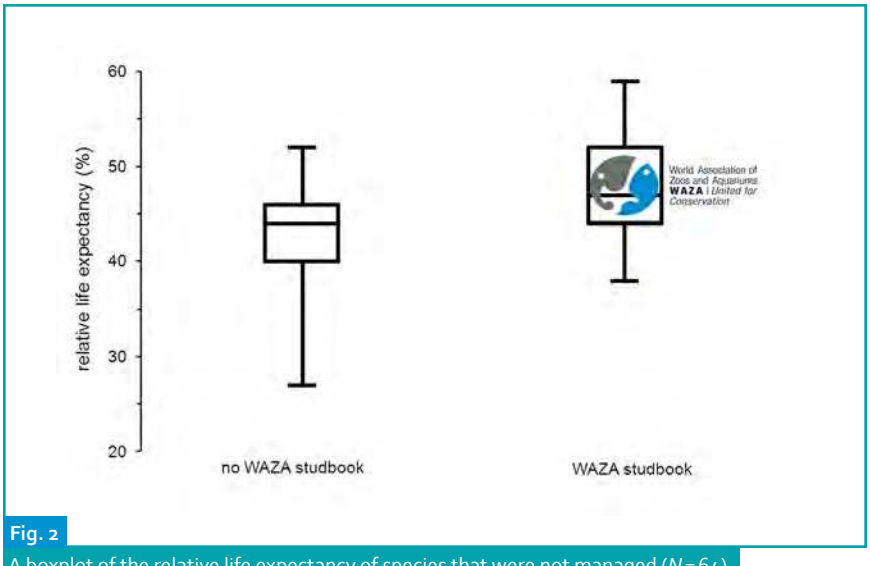

Fig. 2
A boxplot of the relative life expectancy of species that were not managed ($N = 64$) and of species that were managed ($N = 14$) with the help of an international studbook. In descending order, the boxplots show the highest value, the value achieved by 75% of species, the value achieved by 50% of species, the value achieved by 25% of species and the lowest value of the relative life expectancy. Note that species that were managed with an international studbook had a higher relative life expectancy compared with species without such management.

tions including spatial requirements, housing facilities, group size and composition and feeding regimes are often an integral part of these studbooks. The relative life expectancy was higher in species managed with the help of an international studbook kept under the auspices of WAZA (Fig. 2; Müller *et al.* 2010b, 2011). Consequently, the success of such intensive population management seems to be reflected in the higher life expectancy of studbook-managed species.

Although it is unknown whether efforts to reduce inbreeding in studbook-managed populations as compared to species without an international studbook, or the implementation of detailed husbandry guidelines, have also contributed to the higher relative life expectancies of the relevant species, this finding should encourage more intensive use of studbook coordination in additional species.

Conclusions

Our results identified species that live under suboptimal husbandry conditions (e.g. moose); additional efforts should be undertaken to improve these. Furthermore, we identified biological characteristics of species relevant to their life expectancy in captivity, such as natural diet, which should be considered in further improving husbandry success in zoos. Finally, we demonstrated that intensively managing a population with the help of an international studbook has a positive effect on the husbandry success of the respective species.

Acknowledgements

We thank the Georg and Bertha Schwyzer-Winiker-Stiftung and the Vontobel-Stiftung for financial support, WAZA for enabling the data transfer from ISIS and all participating zoos for their consistent data collection.

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